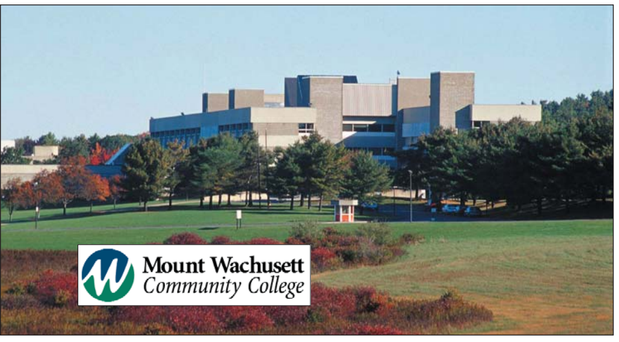
WOOD STRUCTURE AND PROPERTIES. . .

Mount Wachusett Community College in Gardner, Mass. and Wood Digest *have teamed up to present a series of college-level wood technology courses. This is the ninth in the series.*

By Ken Hanson, Wood Technologist

THE FOREST AND WOOD PRODUCTS Institute at Mount Wachusett Community College (MWCC) in Gardner, Mass. has partnered with *Wood Digest* magazine to present a series of college-level wood technology courses. Readers may enroll at MWCC on a distance learning basis for college credit. The courses will be taught using a popular wood technology textbook, coupled with online lessons, discussions and exams. The online component will use the MWCC Distance Learning System known as "Blackboard."

Over the next two years, *Wood Digest* magazine will publish monthly articles based on the course content from the MWCC Wood Products Technology curricula. The initial course is titled "Wood Structure and Properties." Material from this course will be featured through to September 2003. Immediately following, the second course, Wood Machining will continue on to September '04.



For college credit, application and registration information about this Distance Learning Course, please follow these step-by-step procedures:

Step 1. Open *Wood Digest* courses at http://www.mwcc.mass.edu/HTML/FWP/default.html.

Step 2. Open either the course registration form and/or syllabus for your review.

Step 3. Print out the registration form and fill in all of the requested blanks.

Step 4. Mail, fax or scan/e-mail the registration form to the Forest and Wood Products Institute. The numbers, addresses and fees are preprinted on the form.

Step 5. Contact the instructor Ken Hanson at (978) 630-9179 or khanson@mwcc.mass.edu with any questions you may have.

Step 6. Upon registration confirmation, the Institute will e-mail you a welcoming packet of information. You must have Internet access to enroll in this class. Students may enroll in this course ANYTIME throughout the 12-month period, with completion in September '03. There is NO maximum number of students.

This series of *Wood Digest* articles will highlight specific topics, guiding both students and readers through the technological uses of wood, enabling them to become better in our chosen profession. Students who enroll in this Web course will also take quizzes, exams, form discussion and study groups as well as receive three undergraduate credits which may be used toward the completion of a degree at MWCC or selected college.

To all new students and readers: MWCC and *Wood Digest* are excited to offer these Wood Technology courses in this new, exclusive format. We are currently enrolling students into this course at the college and can easily get you caught up with the rest of the class. Your questions and comments are beneficial to us all as we continue this Wood Structure and Properties wood technology course. If you have a comment pertaining to any of the articles, please forward to me at khanson@mwcc.mass.edu. I will utilize as many points of view as possible when describing the nature of wood.

ADHESIVES AND WOOD — PART 9 OF 12

The joining of wood is a necessary tool that all woodworkers will use in the wood products industry. For example, the furniture industry utilizes adhesives to produce panels for door and seat blanks, case ends and bookcase parts. The composite panel manufacturers use adhesives to produce plywood and particleboard, **OSB** and **flakeboard**. Engineered wood product manufacturers produce laminated veneer lumber, laminated strand lumber, glu-lam beams, wood I-joists, etc. All of these products rely on adhesives to bond wood fibers, veneers, **fingerjointed** material and to assemble components. Artisans from the millwork industry use adhesives to produce their unique items, custom-made for their customers.

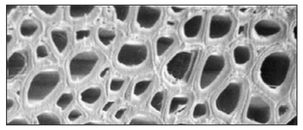
Adhesives used in wood products manufacturing are only a small part of the adhesive types required in the global industrial market. Natural or commonly referred to as "Green" adhesives include carbohydrate-based products such as starch and protein-based products (gluten, casein, soya, and wheat). The adhesives used in wood products are made from a variety of natural and man-made chemicals. Additionally, some wood products are also used in the production of adhesives. For example, wood bark pyrolysis oil may be combined with various chemicals to produce a slower-curing but equally strong adhesive product.

Adhesive requirements:

The design of an adhesive for wood must accomplish four key tasks for the bond to be strong. These four key tasks are flow, penetration, wetting and cure of the applied adhesive film. An explanation of these items is as follows:

Flow:

Normal flow of an adhesive allows **transfer** of the adhesive to all applied surfaces. Upon the application of pressure, adhesive should continue to flow filling minor imperfections, cellular cavities and attain a small level of **squeeze-out**. Improper flow will be characterized by inadequate application to surfaces and excessive squeeze-out, resulting in weak joints. Causes of excessive flow may result from extreme clamping pressure, tight grained woods such as hard maple, or improper manufacturing of the joint edges.



Penetration:

Proper flow will allow the adhesive to penetrate the top few layers of wood cells. Flowing into the vessels, fibers, tracheids, and other cellular cavities, adhesives may continue to wet the surfaces of these cells. Mechanically, the strength of a joint is increased by proper penetration, effectively allowing the adhesive to intertwine into the cell cavities.

Wetting:

As the adhesive flows and penetrates over the joint's wood structure, it must chemically bond to the molecules of the wood. With respect to aqueous (water-based) adhesives, the water in the adhesive may be drawn away too quickly if the wood substrate (adherend) is extremely dry. Conversely, wet wood may not allow adequate penetration and wetting resulting in improper flow and weak joints. In either case, **dry or starved joints** produce weak joints and eventual **wood failure** when the joint is put under stress. The solids portion of the adhesive will remain and minor wood failure will be evident.

Curing or solidification:

Either by chemical reaction or by the removal of water, an adhesive must solidify after proper flow, penetration, and wetting has occurred. This solidification process produces a glue line strength property called **cohesion**. Additional strength of the joint is attained mechanically from the flow, wetting and penetration properties as it solidifies in the cellular cavities, effectively anchoring the adhesive to the substrate.

Chemically, these four key tasks must occur in order to produce a solid bond. Woodworkers are constantly aware of the many obstacles which may inhibit the production of the strongest joint possible. Lets look at a "Case in Point" to help explain a possible situation:

CASE IN POINT!

Fact! Production is behind schedule. Prior to testing the samples, the decision is made to pull the lumber from the kiln and process it for the production of glued furniture parts. After planing and milling 50,000 bd. ft., the process of gluing is taking place. After panels are produced, several splits are noticed on the glue lines of the initial panels produced. Further inspection reveals additional splits. Subsequently, the decision is made that the entire order needs to be redone. Assuming complete production time lost and the requirement to reproduce the parts, any profit for this job is lost and production is now further behind than ever. I hope this has never happened to anyone.

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WHAT WERE THE POSSIBLE CAUSES?

Moisture content of the lumber:

The consistency of the MC percentages is equally important.

For the typical adhesives used in solid wood furniture manufacturing, the optimum moisture content of the adherends should be 7 percent +/-2 percent MC. The consistency of the MC percentages is equally important. For example, if the MC of one part of the panel is 5 percent MC, and the neighboring parts are 9 percent MC, unequal shrinkage of the parts will occur. This unequal shrinkage will apply excessive stresses to the glue line and the surrounding parts. Although shrinkage of this kind may be minor, it may result in table leaves and cabinet doors that fit incorrectly. Regarding the above example, the lumber was used prior to the equalization phase of the charge of lumber. The lumber had various MC readings with some of the load much drier than the rest. The water was drawn very quickly from the joint, resulting in a dry or starved joint.

Whenever new woods are introduced or a change in the production process interacts with the gluing process, problems may develop. Be very cautious!!

Stress in the lumber:

The lumber in the above example was never stress relieved (conditioning phase). Due to the weakened glue joints, inherent stresses were strong enough to cause the cohesive bond (if there was one!) to break, resulting in very little wood failure. Further investigation revealed parts were bowed prior to gluing, and the clamps could not draw the parts together, minimizing transfer, flow, penetration and wetting.

Gluing edge surface quality:

Excessive stress produced poor saw cuts and bowed parts. The parts had a deviation from straight of 1.5 in. The best glue joint edges are ones that are straight, flat, square to the surfaces and have a diamond effect from the ripsaw saw blade. If an edge is made from a jointer, care should be taken to maintain a square, straight, flat surface, free from nicks and other imperfections caused by defective tooling. Adhesives have the ability to fill in small gaps; however, quality glue joint preparation will produce quality glued joints.

TRY IT YOURSELF

To all readers and students: To explore the discussion topics, you can follow along at home or at work. Due to the nature of information presented, it may be difficult to relate to the subject matter. Try surfing the Internet using the keywords from this article. Gather more information about the subject. If you find some good articles, please let the class know about them on Blackboards Discussion Board or e-mail to me.

The keywords are:

1.) Adhesives
2.) OSB
3.) Fingerjointed material
4.) Casein
5.) Transfer
6.) Wood failure
7.) Adherend
8.) Cohesion

For enrolled students: As part of your homework, April's homework and quiz questions are now due. A May '03 homework assignment and quiz are available for you on Blackboard. If you have any questions about Blackboard or the homework, contact me or review the help section available on the MWCC website. WD

Why is a glued joint stronger than the wood itself?

Extensive testing of the adhesives used in the wood products industry has taken place to ensure that the key tasks of the adhesive work consistently in the proper conditions. The adhesive will join wood mechanically and chemically and produce the cohesive strength necessary to be stronger than strength of the surrounding wood components. Whenever new woods are introduced or a change in the production process interacts with the gluing process, problems may develop. Be very cautious!!

All articles edited by David Damery, Building Materials and Wood Technology Department-UMASS-Amherst, Mass.

Wood: Influence of Moisture on Physical Properties by John F. Siau

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